ARJUNA

JEE

LECTURE - 07

Atomic structure

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Q. The ground state energy of hydrogen atom is –13.6eV. The energy of second excited state (n=3) of He^+ ion in eV is ______.

50 Sec

A — 54.4

B — 3.4

C — 6.04 ev ✓

D — 27.2

2nd excited state = $n = 3$

$Z = 2 \ (He^+)$

$$T.E = -13.6 \times \frac{Z^2}{n^2} \text{ ev/atom}$$

$$T.E. = -13.6 \times \frac{(2)^2}{(3)^2}$$

$$= \frac{-13.6 \times 4}{9}$$

$$= -6.04 \text{ ev}$$

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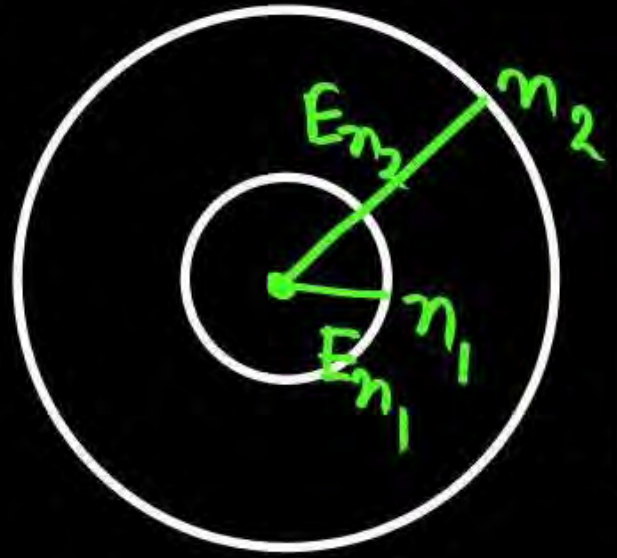
$\underline{C_{SD} = 17}$

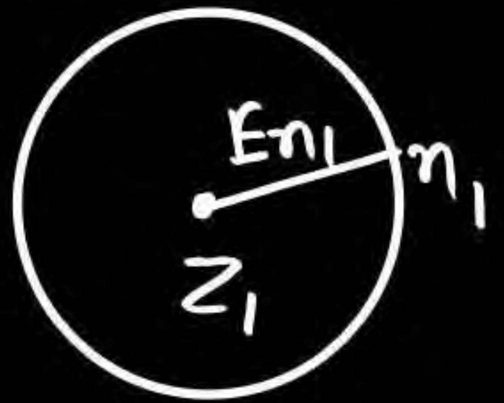
→ Relation of T.E. of different orbits in same atom

$$T.E = -13.6 \times \frac{Z^2}{n^2} \text{ eV/atom}$$

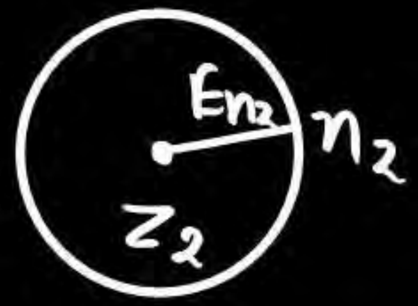


$$\frac{E_{n_1}}{E_{n_2}} = \frac{n_2^2}{n_1^2}$$

②



(A)



(B)

$$\frac{E_{n_1}}{E_{n_2}} = \left(\frac{Z_1}{Z_2}\right)^2 \left(\frac{n_2}{n_1}\right)^2$$

Q. The energy of second Bohr orbit of the hydrogen atom is –328 kJ mol^{-1}, hence the energy of fourth Bohr orbit would be:

$n_1 = 2$, $Z = 1$, $E_{n_1} =$ –328 kJ

$n = 4$, $Z = 1$, $E_{n_2} = ?$

A –41 kJ mol^{-1}

B –1312 kJ mol^{-1}

C –164 kJ mol^{-1}

D –82 kJ mol^{-1} ✓

(M-1) $T.E = -13.6 \times \frac{Z^2}{n^2}$ eV/atom

$E_2 = -13.6 \times \frac{(1)^2}{(2)^2}$ — (I)

$E_4 = -13.6 \times \frac{(1)^2}{(4)^2}$ — (II)

$\frac{-328\text{ KJ}}{E_4} = \frac{(4)^2}{(2)^2} = 4$

$E_4 = -\frac{328}{4}\text{ KJ} = -82\text{ KJ}$

Csp

(M-2) $\frac{E_2}{E_4} = \frac{n_4^2}{n_2^2} \Rightarrow \frac{-328}{E_4} = \frac{(4)^2}{(2)^2} \Rightarrow E_4 = \frac{-328}{4}\text{ KJ}$

$= -82\text{ KJ}$

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Q total energy of 2nd orbit of Li^{+2} ion is $-E_1$ KJ/mole.
Calculate total energy of 3rd orbit of He^{+} ion

(a) $-\frac{E_1}{9}$ KJ/mole

(b) $-\frac{4E_1}{9}$ KJ/mole

(c) $= -\frac{2E_1}{3}$ KJ/mole

✓ (d) None of these

Sol^n

$$\frac{E_{Li^{+2}}}{E_{He^{+}}} = \left(\frac{Z_{Li^{+2}}}{Z_{He^{+}}}\right)^2 \left(\frac{n_{He^{+}}}{n_{Li^{+2}}}\right)^2$$

$$\frac{-E_1}{E_{He^{+}}} = \left(\frac{3}{2}\right)^2 \times \left(\frac{3}{2}\right)^2$$

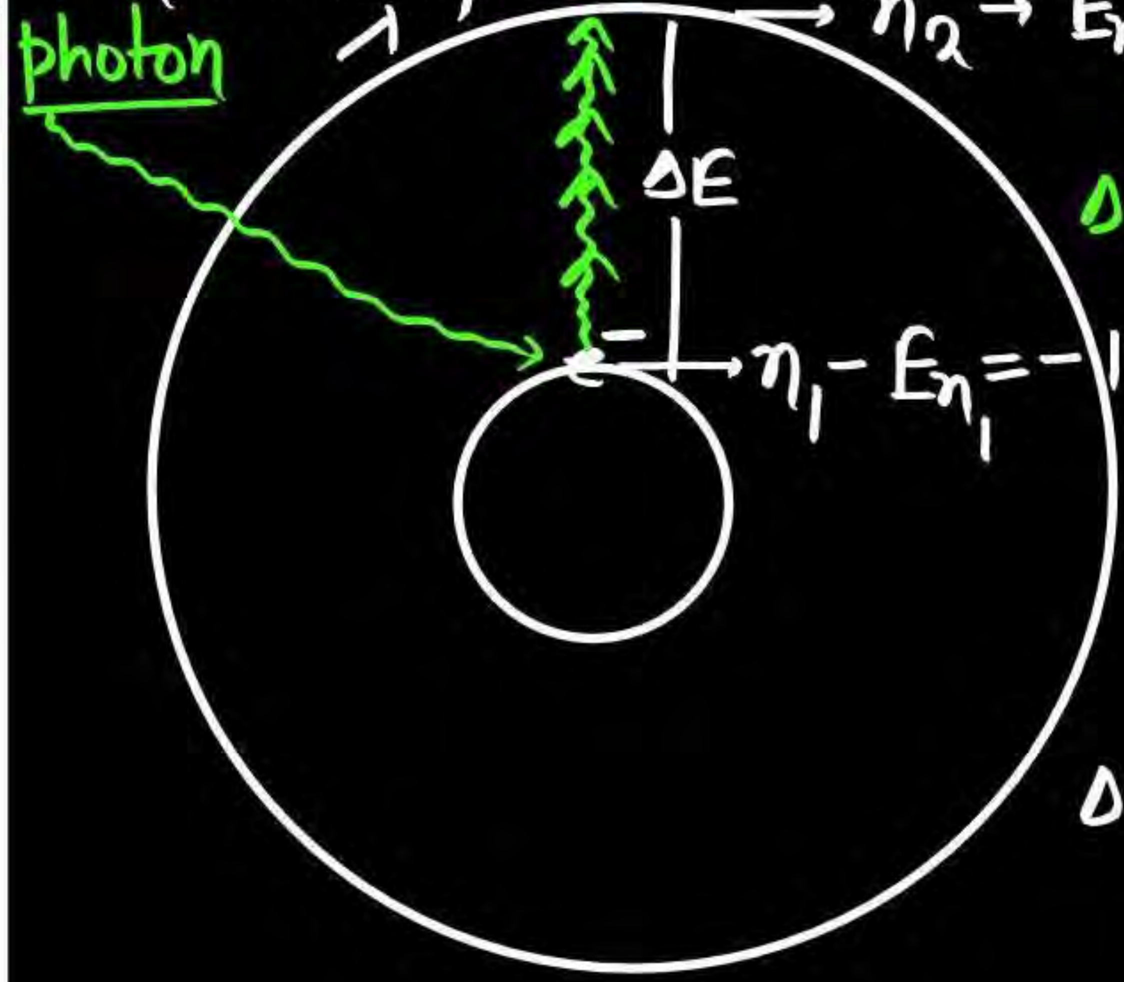
$$\frac{-E_1}{E_{He^{+}}} = \frac{81}{16}$$

$$E_{He^{+}} = -\frac{16E_1}{81} \text{ KJ/mole}$$

$C_{SD} = 18(a)$

$\bar{e}$ jump lower orbit to higher orbit $\Rightarrow$ photon absorbed

$\left(h\nu = \frac{hc}{\lambda}\right)$



$\rightarrow n_2 \rightarrow E_{n_2} = -13.6 \times \frac{Z^2}{n_2^2}$ ev/atom

$\Delta E = |E_{n_2} \sim E_{n_1}|$

$\rightarrow n_1 - E_{n_1} = -13.6 \times \frac{Z^2}{n_1^2}$ ev/atom

$$\Delta E = -13.6 \times \frac{Z^2}{n_2^2} - \left(-13.6 \times \frac{Z^2}{n_1^2}\right)$$

$$= 13.6 \times Z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

Energy of absorbed photon = ΔE

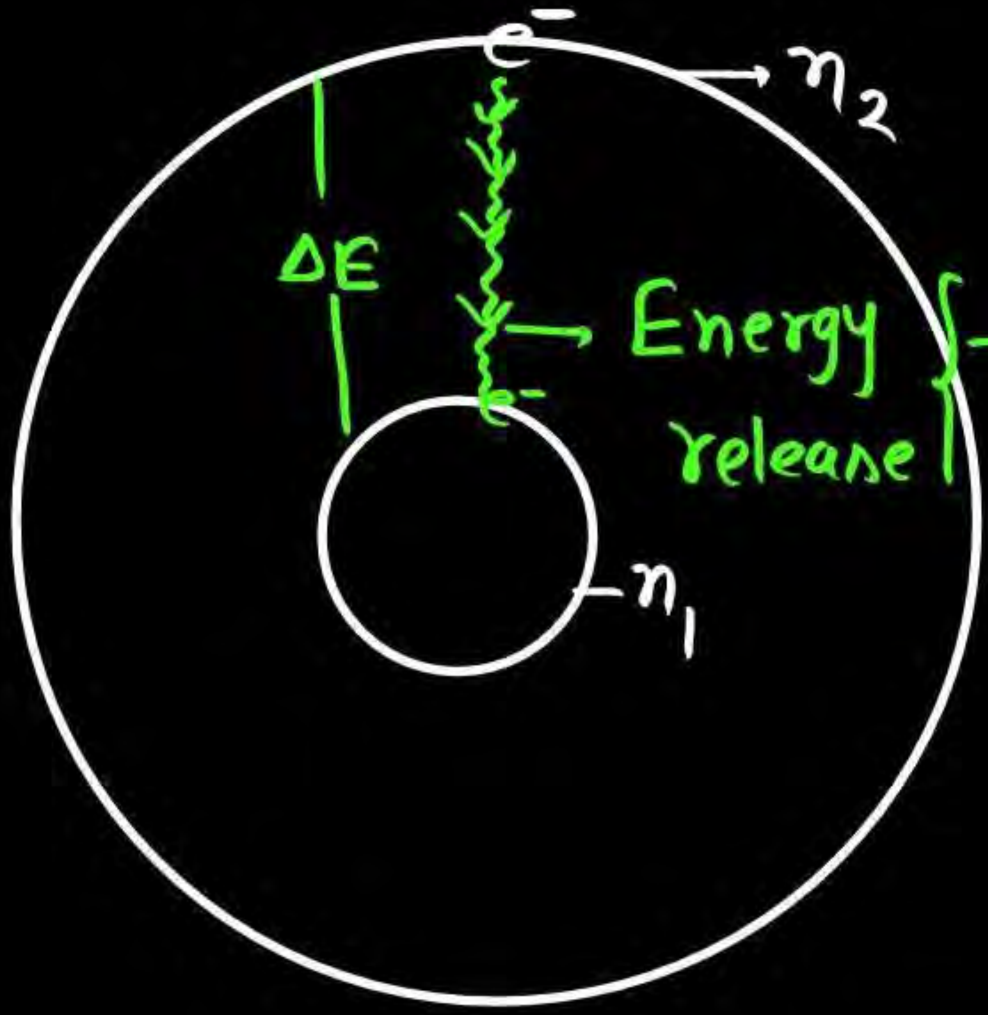
$$h\nu = \frac{hc}{\lambda} = \Delta E$$

$$\frac{hc}{\lambda} = 13.6 \times Z^2 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] ev$$

λ → wavelength of photon (absorbed)

$C_{SD} = 18(b)$

$\bar{e}$ jump higher orbit (n_2) to lower orbit (n_1) = photon release



→ Energy release in term photon $\left(\frac{hc}{\lambda}\right)$

$$\frac{hc}{\lambda} = |\Delta E|$$

$$\frac{hc}{\lambda} = 13.6 \times Z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) eV$$

λ → wavelength of emitted photon

yadi e^- jump krta hai lower $\rightleftharpoons$ higher orbit $\Rightarrow$ to nikalne or absorb krne wale photone ki wavelength (λ)

$$h\nu = \frac{hc}{\lambda} = 13.6 \times Z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \times 1.6 \times 10^{-19} \text{ Joule}$$

Q24. The frequency of radiation emitted when the electron falls from n = 4 to n = 1 in a hydrogen atom will be (Given ionisation energy of H = 2.18×10^{-18} J atom^{-1} and h = 6.625×10^{-34} Js)

(a) $1.54 \times 10^{15}\ s^{-1}$

(b) $1.03 \times 10^{15}\ s^{-1}$

(c) $3.08 \times 10^{15}\ s^{-1}$

(d) $2.00 \times 10^{15}\ s^{-1}$

$$h\nu = 13.6 \times Z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) eV$$

$$6.625 \times 10^{-34} \times \nu = 13.6 \times (1)^2 \left(\frac{1}{(1)^2} - \frac{1}{(4)^2}\right) \times 1.6 \times 10^{-19}\ \text{Joule}$$

$$6.625 \times 10^{-34} \times \nu = 13.6 \left(\frac{15}{16}\right) \times 1.6 \times 10^{-19}$$

$$\nu = 3.08 \times 10^{15}\ \text{Sec}^{-1}$$

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Q.

Subjective Questions

The energy of the electron in the second and third Bohr's orbits of the hydrogen atom is -5.42×10^{-12} erg and -2.41×10^{-12} erg respectively. Calculate the wavelength of the emitted light when the electron drops from the third to the second orbit.

$n=3$ $\quad$ $n=2$ $\quad$ (IIT-JEE = Adv)

$$\frac{hc}{\lambda} = 13.6 \times Z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \times 1.6 \times 10^{-19} \text{ Joule}$$

$$\frac{6.6 \times 10^{-34} \times 3 \times 10^{8} \frac{m}{sec}}{\lambda} = 13.6 \times (1)^2 \left(\frac{1}{4} - \frac{1}{9}\right) \times 1.6 \times 10^{-19}$$

Homework

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[2017 Main]

Energy of electrons is given by

$$E = -2.178 \times 10^{-18} J \left(\frac{Z^2}{n^2}\right)$$

Wavelength of light required to excite and electron in a hydrogen atom from level n = 1 to n = 2 will be ______.

(A) 1.24×10^{-7} m

(B) 2.816×10^{-7} m

(C) 6.500×10^{-7} m

(D) 8.500×10^{-7} m

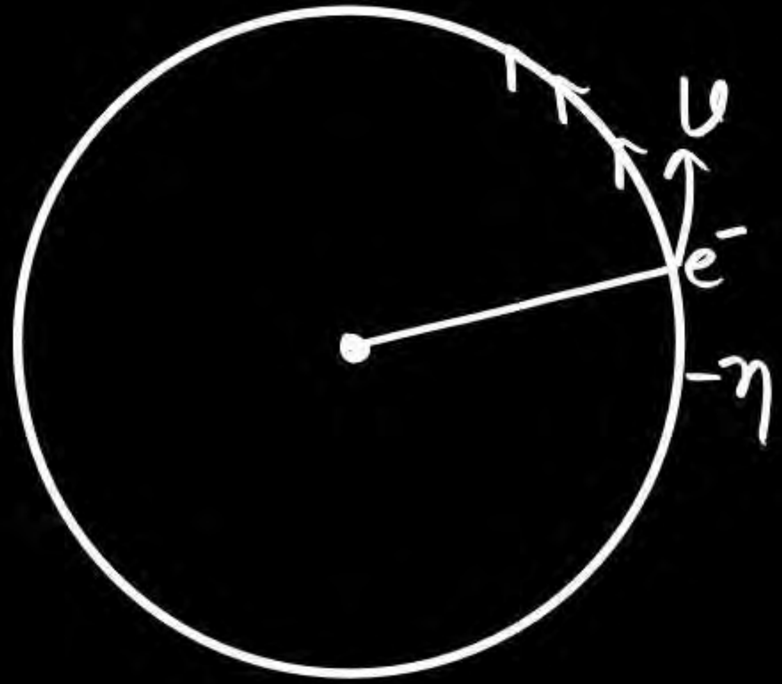
$$\frac{hc}{\lambda} = 13.6 \times Z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \times 1.6 \times 10^{-19} \text{ Joule}$$

$$\frac{6.6 \times 10^{-34} \times 3 \times 10^8}{\lambda} = 2.178 \times 10^{-18} \left(\frac{3}{4}\right)$$

$$\lambda = 12.12 \times^{-8} m$$

$$\lambda = 1.212 \times 10^{-7} \text{ metre}$$

velocity ofelectron



$$u_\eta = 2.188 \times 10^8 \times \frac{Z}{\eta}\ \text{Cm|Sec}$$

where → u_η = velocity of η^{th} orbit revolving e^-

η = No. of orbit

Z = Atomic No. of Species

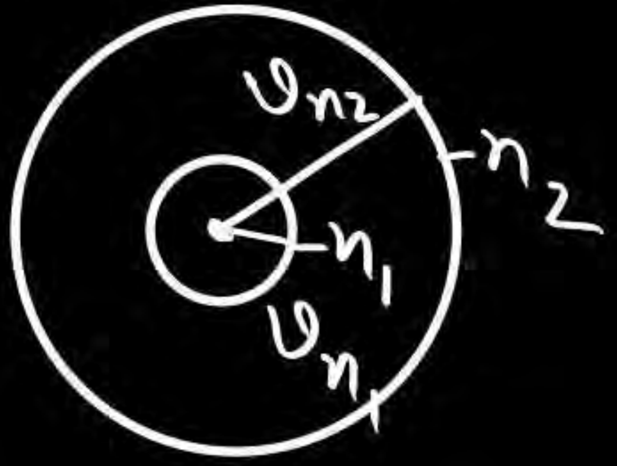
C_{SD}

$$u = 2.188 \times 10^{8} \times \frac{Z}{n} \text{ cm/sec}$$

(i) $u \propto Z$

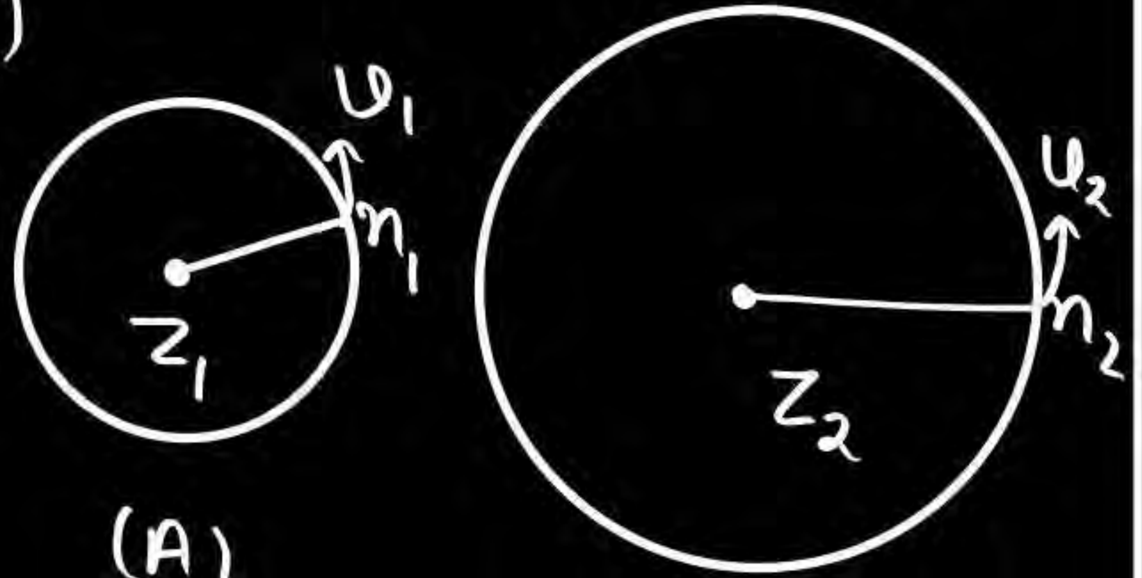
(ii) $u \propto \frac{1}{n}$

(iii)



$$\frac{v_{n_1}}{v_{n_2}} = \frac{n_2}{n_1}$$

(iv)



(A) (B)

$$\frac{u_{n_1}}{u_{n_2}} = \left(\frac{Z_1}{Z_2}\right) \times \left(\frac{n_2}{n_1}\right)$$

Q Calculate velocity of $\bar{e}$, which is revolving in 3^{rd} orbit of He^+ ion.

Soln → $v = 2.188 \times 10^8 \times \frac{Z}{n}$ cm/sec

$Z = 2 \ (He^+)$

$n = 3$

$v = 2.188 \times 10^8 \times \frac{2}{3}$

$= 1.45 \times 10^8$ cm/sec

Q. The electronic velocity in the fourth Bohr's orbit of hydrogen is V. The velocity of the electron in the first orbit would be:

A 4 V ✓

B 16 v

C V/4

D V/16

40-50sec

Sol^n

$$\frac{u_4}{u_1} = \frac{n_1}{n_4} = \frac{1}{4}$$

$$\frac{V}{u_1} = \frac{1}{4}$$

$$\boxed{u_1 = 4v}$$

Time period of revolving e^-

T = Time period = total time required to complete 1 circle

$$T = 1.5 \times 10^{-16} \times \frac{n^3}{Z^2} \text{ sec}$$

→ $T \propto n^3$ → $\frac{T_{n_1}}{T_{n_2}} = \left(\frac{n_1}{n_2}\right)^3$

→ $T \propto \frac{1}{Z^2}$

→ $T \propto \frac{n^3}{Z^2}$

Q time period of revolving of 1st bohr's orbit of H-atom is t sec. than calculate time period of 2nd bohr's orbit of H-atom

✓ (a) 8t (b) $\frac{t}{8}$, (c) t

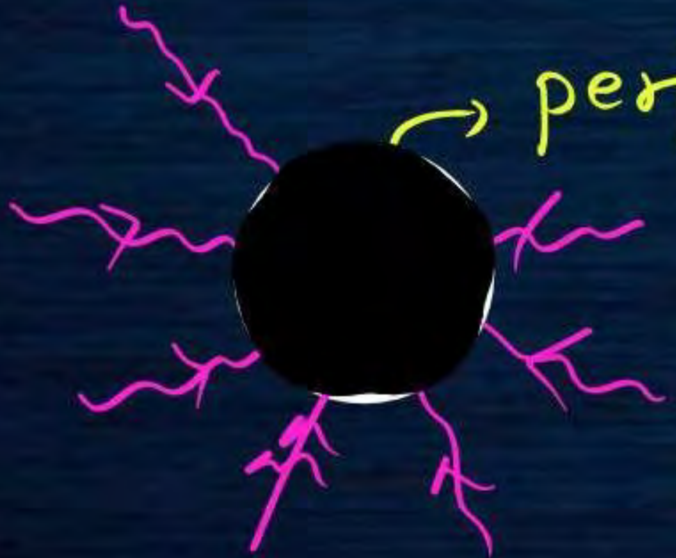
(d) None of these

Soln $\frac{T_1}{T_2} = \left(\frac{n_1}{n_2}\right)^3 = \left(\frac{1}{2}\right)^3$

$\frac{t}{T_2} = \frac{1}{8}$, $T_2 = \underline{\underline{8t \text{ Sec}}}$

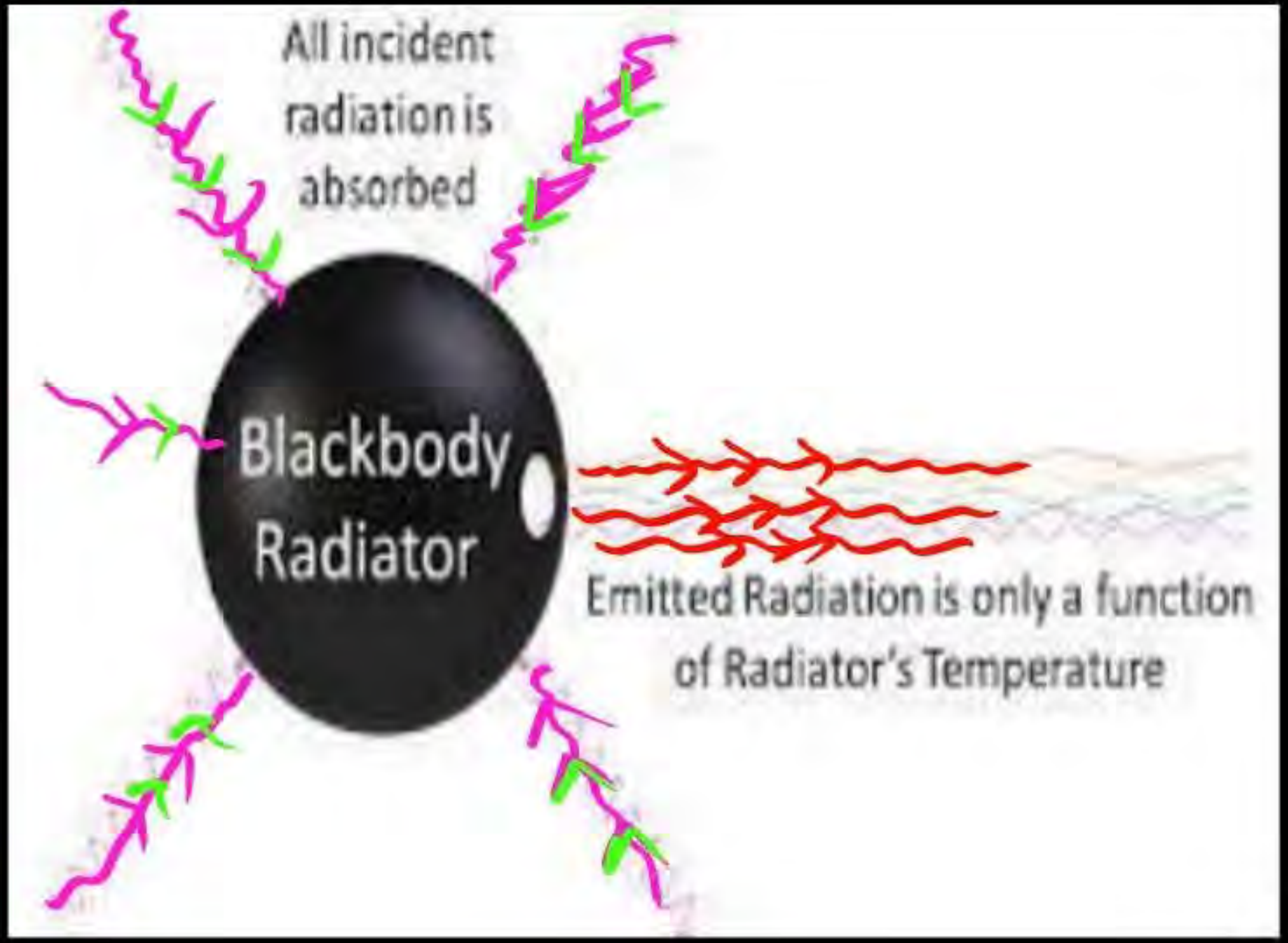
BLACK BODY RADIATION

Perfect Black Body → absorbed all type of wavelength and frequency



→ perfect black body → but generally black Body emitted radiation after absorbed all type of λ and ν

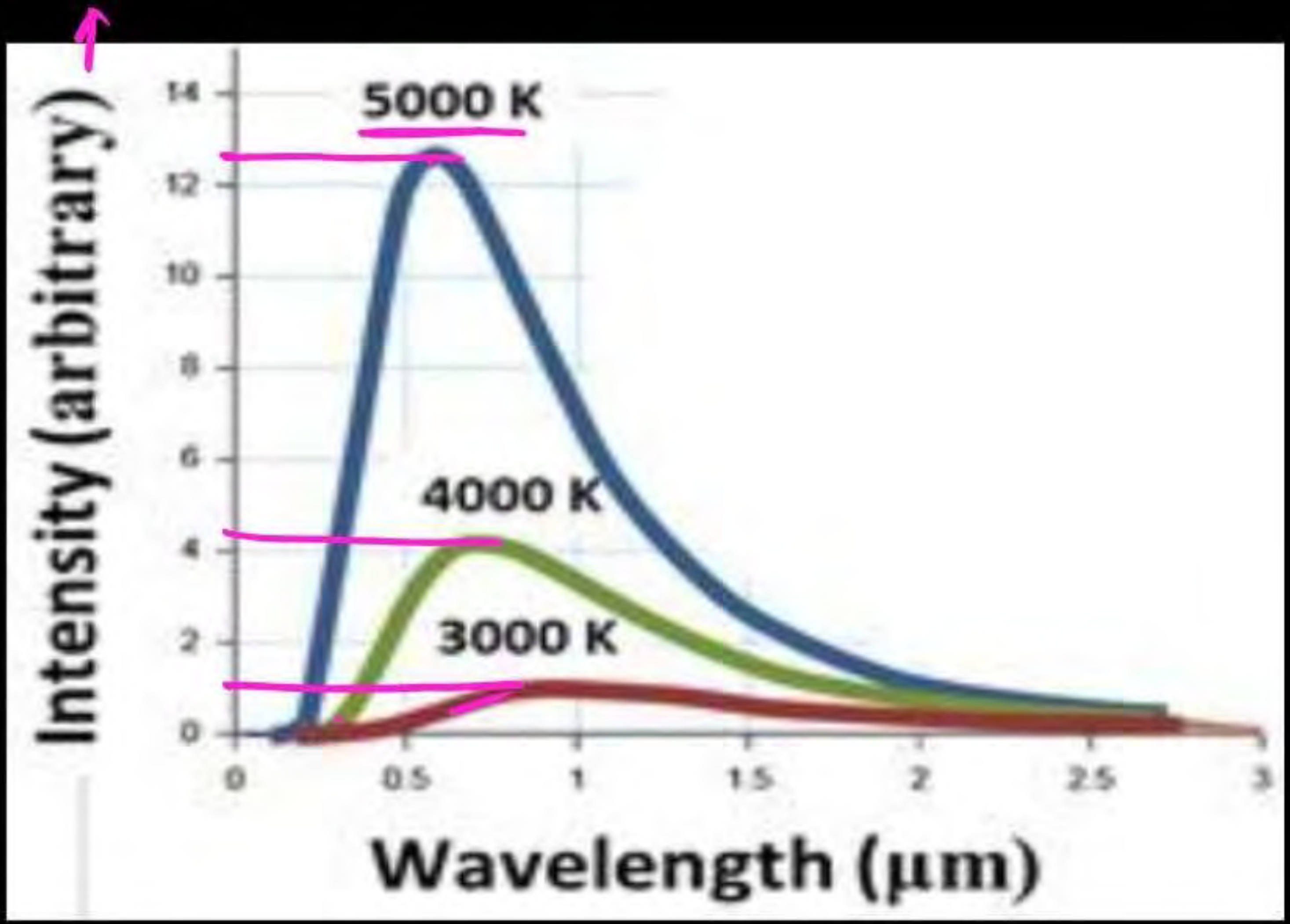
⇒ Intensity of emitted radiation $\propto$ tempera-ture



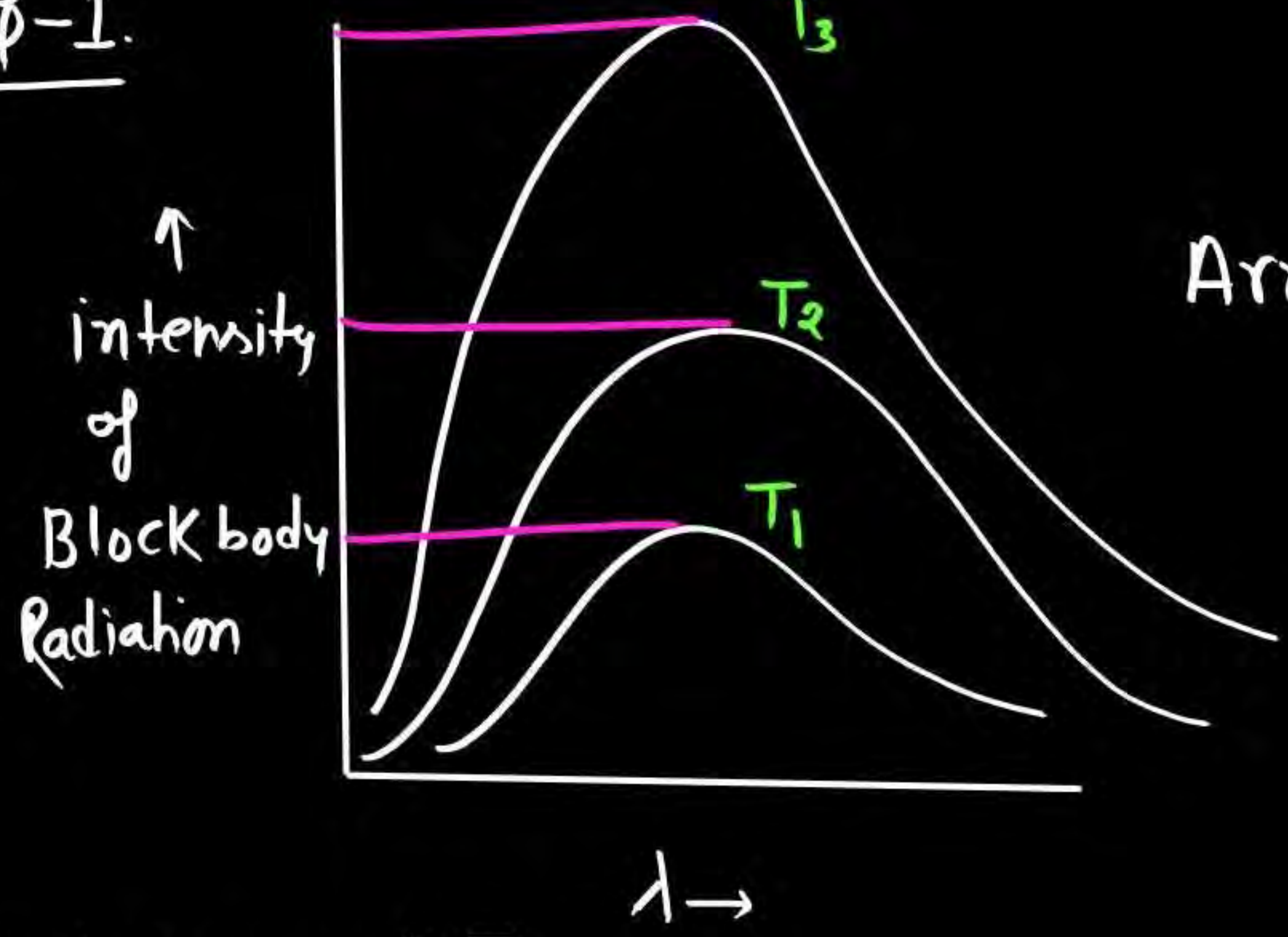
$$I = f(T)$$

↑ temperature → Intensity → ↑

Intensity ∝ (temperature)



Q-1.



Arrange → T_1, T_2 & T_3

Intensity $\propto$ temp.

$T_3 > T_2 > T_1$

(a) $T_1 > T_2 > T_3$

(b) $T_1 < T_2 < T_3$ ✓

(c) $T_1 = 2T_2$

(d) $T_3 = \frac{1}{2} T_1$

Q intensity of Radiation of Block body is x_1, x_2 and x_3 at temperature T_1, T_2 & T_3 K. If $T_1 > T_2 > T_3$. select correct Relation

(a) $x_1 > x_2 > x_3$ ✓

(b) $x_1 < x_2 < x_3$

(c) None

(d) $x_1 = x_2 = x_3$

→ Intensity ∝ temperature

→ $T_1 \rightarrow x_1$

$T_2 \rightarrow x_2$

$T_3 \rightarrow x_3$

→ $T_1 > T_2 > T_3$

→ $x_1 > x_2 > x_3$

Home work

DPP 05

Thank - You